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Is Existing Maintenance System Adequate for Sulphur 2020 Amendments?

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ABSTRACT

Sulphur 2020 regulation as a reduction of sulphur emissions has been caused a big challenge via using new fuels in the maritime industry. Consistent changes in the chemical and physical properties of these new fuels make classical maintenance methods as brake down or planned inadequate and endanger operational and navigational safety on ships. Within this framework, ship maintenance systems need to be reevaluated in accordance with the new marine fuels.

In this study, firstly impacts of new marine fuels on ships have been evaluated by means of a literature review. Furthermore, repair and maintenance systems have been presented that are currently used on board ships. Subsequently, advantages of a predictive maintenance system that will reduce risk by constantly monitoring the potential critical characteristics of VLSFO over other maintenance systems have been discussed. Then, assessments of compliance fuel have been done in accordance with fuel properties, problems and corrective actions. Lastly, discussions and suggestions have been provided to the ship owners and technical managements.

Keywords

Sulphur 2020, VLSFO, Predictive Maintenance, Marine Engines.

1. Introduction

Nowadays, ships have faced with new technical problems via using very low sulphur fuel oil as of Sulphur 2020 Regulation which affect many parameters in the maritime industry. There are three major alternative solutions in order to comply with new Sulphur regulation that are firstly using of very low Sulphur fuel oil (VLSFO) or marine diesel oil, secondly exhaust gas cleaning system such as scrubber and thirdly the use of nonpetroleum-based fuels as liquefied natural gas [1]-[3].

SOx emission is not the only component to be controlled on marine diesel engines. Also, a method that reduces SOx emissions should not have an increasing effect on

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other polluting components.

While SOx emissions have been significantly reduced with the scrubber systems as an exhaust gas cleaning system, the additional energy as a fuel consumption for the operation of the system and the neutralization of the acidic washing water in scrubbers will considerably increase the CO_2 emissions [2][4].

In addition, the control of a very complex chemical process complicates the operational process of scrubber. Moreover, using of a separate tank for the storage of sludge generated during the SOx binding of NaOH using in decomposition of SOx and the disposal of the sludge formed at certain intervals causes additional operating costs and increased personnel workloads.

The effects of alternative fuels and exhaust gas cleaning systems which are used to reduce SOx emissions have been compared on the initial investment cost, operating costs, storage requirements and SOx, CO_2 emissions, in Table 1 [2][5][6].

1.1. New Marine Fuels and Impacts on Ships

The approximate number of ships with scrubbers in operation and on order could be determined as 2702 and 2756 by the year of 2020 and 2021, respectively [7]. The rest of ships have been using a low sulphur fuel oil or marine diesel oil with a small modification of engines. As an inside composition of marine fuels, there are kerosene to reduce the viscosity of residues through blending, light and heavy gasoil, diesel, residue fraction with fluid catalytic cracker and visbreaking process. These blends could be produced considering marine fuel standards with maximum density limit that affects ignition quality, maximum silicon and aluminum limits in order to avoid abrasive corrosion inside fuel system; and maximum total sediment limit so as to reduce impurities [2][8].

Hydrotreating, coking and cracking processes remove sulphur in the refinery process [9] which forms inside crude oil from 0.03 to 7.89% [10] by weight. There are negative impacts on producing of large volumes of marine fuel such as unsustainable reliability and lack of experience. For this reason, residues are blended with distillates in refineries so as to obtain low Sulphur fuel oil [2]. This new situation could result with some negative impacts as;

- Negative impacts on combustion chamber of the substances remaining in the fuel as a result of the cracking methods used in obtaining new fuels,
- Negative impact of using wrong cylinder oil with VLFSO on two stroke diesel engine,
- Filtration and separation processes

Table 1. *Comparing of Different Fuels According to Ecologic and Economic Factors [2][5][6]*

	Capital Investments	Operating Costs	Storage	SOx	CO_2
HFO	Low	Low	Unlimited	High	High
HFO/Scrubber	High	Medium	Slightly Limited	Low	High
MGO	Low	Very high	Unlimited	Low	High
Methanol	Very high	High	Limited	Very Low	Very Low
LNG	Very high	Very Low	Limited	Very Low	Low

- Refineries have produced new fuel with different specifications within required Sulphur limits which causes compatibility, stability and waxing problems.

Since there are only chemical tests of new very low Sulphur fuel oil not a tests on marine diesel engines by refineries, the testing and evaluating of the results would be done on existing working ships via try and see method. Unfortunately, this situation strikes the fact that existing ships are used as test tools. Furthermore, the malfunctions and failures that occurred due to very low Sulphur fuel oil could result in detriment of navigational safety and commercial losses.

2. Necessity of New Maintenance System with New VLSFO

Maintenance for the maritime industry includes mandatory requirements that are concern with the maritime regulations. It also has to contribute effective and efficient shipping operations. Furthermore, inspective procedures have been extended due to requirements of classification societies and rule makers [11].

A planned maintenance system which is compulsory application in compliance with International Safety Management (ISM) Code involves schedule tasks. There are also brake down, preventive and predictive maintenance systems which are rarely used on board ships. Conventionally, there are planned and unplanned maintenance systems and also preventive or corrective in compliance with European standard EN 13306: 2017. Furthermore, preventive maintenance can be expressed as time based planned maintenance and conditional maintenance [12][13].

In maritime industry; scheduled replacement, scheduled overhaul, corrective maintenance, continuous on-condition task and scheduled on-condition task are utilized as the maintenance systems [14,15,16]. Essentially, preventive, corrective maintenance and condition based as predictive maintenance approaches have been expressed among the various maintenance systems [14][17][18][19].

Among these, Predictive Maintenance System has become much more important for the maritime industry with the introduction of new VLSFO fuels. The main objective of the predictive maintenance is originated from the current condition of the engines. Moreover, it can be expressed as monitoring of the machinery and abided by its current condition. It also involves sensor selection and betimes or continuous data measurement with different monitoring of performance, lubrication, thermal, acoustic and vibration [20].

From the different viewpoint, predictive maintenance is policy which uses monitoring data of indirect condition so as to estimate forthcoming malfunctions. There are two kind of predictive maintenance model which contains useful life prediction and maintenance optimization. Thus, it can be expressed as statistical, knowledge based and data driven strategies with feature engineering, overfitting, and regularization [21]. As an example of statistical method, speed and fuel consumption data of 14 months were used for the ship performance evaluation [22].

In substance, predictive maintenance have been predicated on early diagnosis of the engine failures which prevents the degradation of engines. In this systems, machineries are fitted with a sensors and data acquisition system which ensure beforetime failure prediction. Therefore, this will result in firstly higher performance of engines, reduction of spare part usage, enhanced profit and decreasing of maintenance costs [23]. Predictive maintenance also provides a decrease in failure risks and costs, enhance performance in despite of higher initial investment costs [24][25][26].

3. Results and Conclusion

3.1. Assessment of the New Compliant Fuels

Using of 0.5% sulphur marine fuels with an increasing number of different fuel blend types have cause problems such as instability incompatibility. Furthermore, fuel lines, filters and tanks have been redesigned in order to decrease the risk of instability and incompatibility [27].

There are some problems about using compliant fuel as low viscosity, compatibility problems, stability and flash point which are about operational and safety subjects [28]. In this respects, Table 2 illustrates the fuel properties, problems and corrective actions of a new compliant fuel.

3.2. Assessment of the Maintenance System with Compliant Fuels

When considered from the new low sulphur fuel's point of view, especially diesel engines have to be constantly observed while working even if specification of the latest receiving fuel is suitable. This is because of compatibility, stability and other negative impacts of low sulphur fuel. Therefore, this will lead to changes in conventional maintenance and monitoring standards on ships.

Traditionally, breakdown maintenance, planned maintenance and preventive maintenance are insufficient as the unexpected impact of using new low sulphur fuel oil. For instance, piston rings, cylinder liner and fuel pumps could be broken after a few hundred hours of operation. Consequently, the planned maintenance systems which are currently used on the ships could be revised by using predictive maintenance in the critical equipment in the ship engine room. Particularly, it could be applied to the fuel systems due to compulsory drydocking processes.

The new type of fuel has not been tested on current marine diesel engines by manufacturers. Hence, its effects are difficult to predict. Furthermore, the corrosive substances inside the fuel were thrown with sulfur. However it sticks directly with the new fuel because of low sulfur and bonding to the metal and becomes corrosive.

In addition to the frequent analysis of fuels and oils for using of newly used low sulphur fuels, scavenge drain oil and flue gas analysis have also become more important. Because, the effect of additives inside the lubricating oils has a different impact on using of new fuels on ships. In other words, the influence on engines of using new fuel should be constantly monitored such as temperatures, pressures, filters and exhaust gas components as required for predictive maintenance.

3.3. Assessment for Ship Owners

- Shipowners as first generation; moved from other industries to maritime industry and became ship owner-operator. When considering of repair and maintenance on marine engines, generally, the first method of brake down maintenance was utilized for maintenance and spare parts. Planned and preventive maintenance are perceived as unnecessary.
- Shipowners as second generation who are the children of the first generation; although reluctant to planned maintenance, international rules and regulations have been obligated to implementation of planned maintenance.
- Third generation shipowners as ship operators; budgets and targets are so crucial however planned maintenance have been implemented in their companies.

In conclusion, shipping companies should have a purchasing department with

planning and reporting. Moreover, risks that will occur when planning or making decisions should be well calculated. Risk assessment has been done. Technical managements of shipping companies has operated shipyard processes, orders, spare part management and engineer officers that are working on ships. Therefore, predictive maintenance has become mandatory in accordance with new fuels

Table 2. *Assessment of Fuel Properties, Problems and Corrective Actions in Accordance with Compliance Fuel*

Fuel Properties	Problem	Corrective Actions
High density [29]	Difficult separation due to unusual density of blend fuel.	To operate the separators serially in Purifier + Clarifier mode, respectively.
High ash content [32]	Excessive corrosion in the piston rings and cylinders. Deposit formation in the exhaust valve, piston ring socket and turbine wings.	Operating the separator with high efficiency and putting filter with low pore diameter (<50μm) in the outlet if necessary.
High vanadium [29]	High temperature corrosion and deposit formation	To use the additives which deactivate the vanadium in order to prevent high temperature corrosion.
Sodium (sea water) [32]	Deposit formation in the turbine wings. Excessive sludge accumulation in the exhaust valves. Deposit formation in the injector nozzle and piston rings.	To operate the separator in low flow rate and high efficiency and to decompose maximum water.
High Al+Si [30]	High corrosion in fuel pumps, cylinder jacket and piston rings.	For classical separators, to operate the separators in serial mode with low flow rate.
Fuel incompatibility [31]	Excessive sludge outlet from the separators, increase of the corrosion in the fuel pumps, deposit formation in the injector nozzle, exhaust valve and turbine.	To perform conformity tests for fuels. If it is not possible to perform compatibility test, to transfer the old fuel in the fuel tanks to other fuels before fuel tank.
High CCAI [29]	Knocking problem	To activate the preheater of the main engine before starting of main engine to keep the engine hot.
Low flash point [31]	Safety storage problem because of lower flash points	Limits to 60 °C according to SOLAS, Protecting fuel leakages in fuel lines and ventilation of service and settling tanks spaces.
Stability [29,30]	Exhibits the potential of particle formation, sediment/gumming during using and storage of fuel due to gravitation of asphaltenes resulting in sludge formation	Not mixing of different fuel blends. Sudden temperature increase and decrease should be avoided during change over period.
Clouding /Pouring [31,32]	It is the flow property in low temperature and affects fuel transfer. High cloud point causes plugging of filters.	Fuel should be heated adequately higher than pour point and probable wax formation point. Thus, the temperature of fuel must keep above 10 °C of cloud Point of VLSFO
Lubricating [30]	Excessive wear on fuel pump and injection valves due to lower sulfur content.	Additives can be used. Measures must be taken that the viscosity will not drop below 2 cSt especially in the transition to low viscosity fuels.

of maritime sectors. Knowledge, skills and experience have become even more important and ship technical management should be done in a more professional way with a separate purchasing, maintenance, education and training department.

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